Acid Base Review Worksheet

For the following acids and bases write the aqueous dissociation reactions, list either the conjugate acid or base species, and write the K_a or K_b expressions.

chlorous acid, hydrosulfuric acid, acetate ion, bicarbonate ion, iron (III) ion, acetic acid

$HClO_2 + H_2O \rightleftharpoons H_3O^+ + ClO_2^-$ (A, B)

$K_a = \frac{[H^+][ClO_2^-]}{[HClO_2]}$

$H_2S \rightleftharpoons H^+ + HS^-$ (A, B)

$K_a = \frac{[H^+][HS^-]}{[H_2S]}$

$C_2H_3O_2^- + H_2O \rightleftharpoons HC_2H_3O_2 + OH^-$ (B, A)

$K_b = \frac{[HC_2H_3O_2][OH^-]}{[C_2H_3O_2^-]}$

$HCO_3^- + H_2O \rightleftharpoons H_2CO_3 + OH^-$ (B, A)

$K_b = \frac{[H_2CO_3][OH^-]}{[HCO_3^-]}$

$Fe^{3+} + 6H_2O \rightleftharpoons Fe(OH)(H_2O)_5^{2+} + H^+$ ($Fe(H_2O)_6^{3+}$: A; B)

$K_a = \frac{[Fe(OH)(H_2O)_5^{2+}][H^+]}{[Fe(H_2O)_6^{3+}]}$

$HC_2H_3O_2 \rightleftharpoons H^+ + C_2H_3O_2^-$ (A, B)

$K_a = \frac{[H][C_2H_3O_2^-]}{[HC_2H_3O_2]}$

Calculate the pH of the following solutions. (You will need to look up K_a or K_b values for weak species).

0.45 M HCl $\rightarrow H^+ + Cl$

$0.45\,M\,HCl \times \frac{1\,mol\,H^+}{1\,mol\,HCl} = 0.45\,M\,H^+$ $pH = -\log(0.45\,M) = \boxed{0.35}$

2.6×10^{-5} M KOH $\rightarrow K^+ + OH^-$

$2.6 \times 10^{-5}\,M\,KOH \times \frac{1\,mol\,OH^-}{1\,mol\,KOH} = 2.6 \times 10^{-5}\,M\,OH^-$ $pOH = -\log(2.6 \times 10^{-5}\,M) = 4.59$ $\boxed{pH = 9.41}$

7.96×10^{-3} M nitrous acid $K_a = \frac{[H][NO_2^-]}{[HNO_2]} = 4.0 \times 10^{-4}$

$HNO_2 \rightleftharpoons H^+ + NO_2^-$

	HNO_2	H^+	NO_2^-
I	7.96×10^{-3}	0	0
C	$-x$	$+x$	$+x$
E	$7.96 \times 10^{-3} - x$	x	x

Assume $[HNO_2] \gg x$

$\frac{x^2}{7.96 \times 10^{-3}\,M} = 4.0 \times 10^{-4}$

$x = 1.78 \times 10^{-2}$

$[H^+] = 1.78 \times 10^{-2}\,M$

$pH = -\log 1.78 \times 10^{-2}\,M = \boxed{1.75}$

9.96×10^{-2} M aniline

$C_6H_5NH_2 + H_2O \rightleftharpoons C_6H_5NH_3^+ + OH^-$

	$C_6H_5NH_2$	H_2O	$C_6H_5NH_3^+$	OH^-
I	$9.6 \times 10^{-2}\,M$	—	0	0
C	$-x$	—	$+x$	$+x$
E	$9.6 \times 10^{-2}\,M - x$	—	x	x

Assume x v. small

$K_b = \frac{[C_6H_5NH_3^+][OH^-]}{[C_6H_5NH_2]} = 3.8 \times 10^{-10}$

$\frac{x^2}{9.6 \times 10^{-2}\,M} = 3.8 \times 10^{-10}$

$x = 6.04 \times 10^{-6}\,M$

$[OH^-] = 6.04 \times 10^{-6}\,M$

$pOH = -\log(6.04 \times 10^{-6}\,M)$

$= 5.22$

$pH = 14 - 5.22 = \boxed{8.78}$

Calculate the percent ionization in 0.10 M HF and 0.010 M HF solutions. $K_a = \frac{[H][F^-]}{[HF]} = 7.2 \times 10^{-4}$

$HF \rightleftharpoons H^+ + F^-$

	HF	H^+	F^-
I	0.1 M	0	0
C	$-x$	$+x$	$+x$
E	0.1 M $- x$	x	x

~~0.1 M ≫ x~~

$\frac{x^2}{0.1\,M} = 7.2 \times 10^{-4}$

$[H^+] = x = 0.0085\,M$

$\%\,diss = \frac{0.00813\,M}{0.10\,M} \times 100\% = \boxed{8.1\%\ dissociated}$

$\frac{x^2}{0.10\,M - x} = 7.2 \times 10^{-4} \Rightarrow x = 0.00813\,M$

$x^2 + 7.2 \times 10^{-4}x - 7.2 \times 10^{-5} = 0$

$\frac{-7.2 \times 10^{-4} \pm \sqrt{(7.2 \times 10^{-4})^2 - 4(1)(-7.2 \times 10^{-5})}}{2(1)}$

Not 5%

$HF \rightleftharpoons H^+ + F^-$

	HF	H^+	F^-
I	0.010 M	0	0
C	$-x$	$+x$	$+x$
E	0.010 M $- x$	x	x

$\frac{x^2}{0.010\,M - x} = 7.2 \times 10^{-4}$

$x^2 + 7.2 \times 10^{-4}x - 7.2 \times 10^{-6} = 0$

$[H^+] = x = 0.00242\,M$

$\%\,diss = \frac{0.00242}{0.010\,M} \times 100\%$

$= 24.2\%$

The solubility of carbon dioxide in pure water at 25.0°C and 0.100 atm of pressure is 0.00037 M. When carbon dioxide dissolves in water an acid forms that is diprotic. Assuming all of the CO_2 in solution is making the acid, what will be the pH of a 0.00037 M solution of this acid? You will need to look up the K_a value for this acid.

$CO_2 + H_2O \rightleftharpoons H_2CO_{3(aq)} \rightleftharpoons H^+ + HCO_3^-$ $K_{a_1} = 4.3\times10^{-7}$ $K_{a_2} = 5.6\times10^{-11}$

$H_2CO_3 \rightleftharpoons H^+ + A^-$

I 0.00037 M 0 0

C $-x$ $+x$ $+x$

E $0.00037\,M - x$ x x

Assume $0.00037\,M \gg x$

$\frac{x^2}{0.00037} = 4.3\times10^{-7}$

$x = 1.26\times10^{-5}\,M = [H^+]$

Assume x is less than 5%

$pH = -\log(1.26\times10^{-5}\,M) = 4.90$

$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$

I 1.26×10^{-5} 1.26×10^{-5} 0

C $-x$ $+x$ x

E 1.26×10^{-5} 1.26×10^{-5} x

Assume $[HCO_3^-]_0 \gg x$ yep

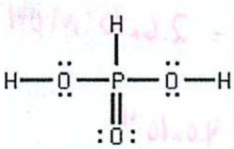
$K_{a_2} = 5.6\times10^{-11} = \frac{x(1.26\times10^{-5})}{(1.26\times10^{-5})} = [CO_3^{2-}]$

So H^+ only comes from H_2CO_3

Which of the following compounds will form a more acidic solution?

i) sodium nitrate or ferric nitrate
ii) potassium bromide or potassium hypobromate
iii) tin (II) chloride or tin (IV) chloride

Phosphorous acid has the following Lewis structure:



i) Explain why H_3PO_3 is diprotic and not triprotic.
ii) A 25.0 mL sample of a solution of H_3PO_3 is titrated completely with 23.3 mL 0.102 M NaOH. What is the molarity of the H_3PO_3 solution?
iii) This solution has a pH of 1.59. Calculate the percent ionization and K_{a1} for H_3PO_3, assuming $K_{a1} \gg K_{a2}$.
iv) How does the osmotic pressure of a 0.050 M HCl solution compare with that of a 0.050 M solution of H_3PO_3? Explain.

i) B/c only the proton attached to oxygen is likely to be given off b/c of O's high e-neg. Thus the O–H bond is easily broken. The third H^+ is not given off b/c P is not as e-neg as O

ii) $H_3PO_3 + 2NaOH \rightarrow 2H_2O + Na_2HPO_3$

23.3 mL NaOH × 0.102 M NaOH × $\frac{1\text{ mol } H_3PO_3}{2\text{ mol NaOH}}$ × $\frac{1}{25.0\text{ mL } H_3PO_3}$ = 0.0475 M H_3PO_3

iii) $H_3PO_3 \rightleftharpoons H^+ + H_2PO_3^-$ $[H^+] = \text{antilog}(-1.59) = 0.026\,M$

I 0.0475 M 0 0

E 0.026 M 0.026 M

% dissoc = $\frac{0.026\,M}{0.0475\,M} \times 100\% = 55\%$ dissoc

iv) $\Pi_{HCl_{(aq)}} > \Pi_{H_3PO_{3(aq)}}$ B/c there are more particles in HCl(aq) since it fully dissociates. The H_3PO_3 does not fully dissociate so it will have a lower # of particles, thus lower Π